Is intake of sugar-sweetened beverages associated with adiposity in children?

Conclusion

Strong evidence supports the conclusion that greater intake of sugar-sweetened beverages is associated with increased adiposity in children.

Grade: Strong

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades click here.

Evidence Summary Overview

The Dietary Guidelines Advisory Committee (DGAC) conducted a full Nutrition Evidence Library (NEL) search to evaluate the association between sugar-sweetened beverages and adiposity in children. Results of this review, covering 2004 to 2009, were supplemented by the findings of prospective studies included in an earlier evidence review conducted by the American Dietetic Association (ADA) (1982 to 2004). In combination, the two systematic literature searches identified 19 peer-reviewed articles that addressed the research question, seven studies from the earlier ADA review and 12 studies from the subsequent NEL review. This included two RCTs (Ebbeling, 2006; James, 2004); 17 longitudinal studies [six from the ADA review (Ludwig, 2001; Philipis, 2004; Sugimori, 2004; Mrdjenovic, 2003; Newby, 2004; Berkey, 2004) and 11 from the NEL review (Blum, 2005; DuBois, 2008; Fiorito, 2009; Johnson, 2007; Kral, 2008; Kvaavik, 2005; Libuda, 2008; Mundt, 2006; Striegel-Moore, 2006; Tam, 2006; Welsh, 2005)]. Ten of the studies were conducted in the US; the others were conducted outside of the US.

Overall, the majority of included studies (12 of 19) found a positive association between sugar-sweetened beverage (SSB) intake and adiposity in all or a subsample of the population studied. Of these studies, two were randomized controlled trials (RCTs) (Ebbeling, 2006; James, 2004) and 10 were longitudinal cohort studies (DuBois, 2008; Fiorito, 2009; Kral, 2008; Libuda, 2008; Striegel-Moore, 2006; Tam, 2006; Welsh, 2005; Ludwig, 2001; Philips, 2004; Berkey, 2004). Six other studies, all of a longitudinal design, found no association between SSB intake and adiposity in children (Johnson, 2007; Kvaavik, 2005; Mrdjenovic, 2003; Mundt, 2006; Newby, 2004; Sugimori, 2004).

Both RCTs included in the review reported some results consistent with a positive association between intake of SSBs and adiposity in children. In the study by Ebbeling et al (2006), children in the upper third of the BMI distribution at baseline reduced adiposity subsequent to reducing intake of SSBs, and the RCT conducted by James et al (2004) found that a targeted, school-based education program that produced a modest reduction in the number of carbonated drinks consumed, was associated with a reduction in the number of overweight and obese children.

Evidence Summary Paragraphs

Randomized Controlled Trials (2)

Ebbeling et al, 2006 (positive quality) conducted an RCT in the US to examine the effect of decreasing SSB consumption on body weight in adolescents. Subjects in the intervention group received weekly home deliveries of non-caloric beverages for 25 weeks, with a target consumption of four servings per day, while those in the control group were asked to continue their usual beverage consumption habits. Two 24-hour dietary and physical activity recall interviews were conducted at baseline and after 25 weeks, and weight and height were measured as well. The final sample included 103 adolescents (53 in the intervention group, 50 in the control group; mean age = 16 years). Consumption of SSBs decreased by 82% in the intervention group (P<0.0001), while consumption in the control group remained the same. Change in BMI was 0.07 ± 0.14kg/m^2 in the intervention group and 0.21 ± 0.15kg/m^2 in the control group, however, the difference between groups (-0.14 ± 0.21kg/m^2) was not statistically significant (NS). However, baseline BMI was a significant effect modifier; among subjects in the upper baseline BMI tertile, BMI changed differed between the intervention (-0.63 ± 0.23kg/m^2) and control groups ($+0.12\pm0.26$kg/m^2), and the difference (-0.75 ± 0.34kg/m^2) was significant (P=0.03).

James J et al, 2004 (positive quality) conducted an RCT in the United Kingdom to determine if a school-based educational program for reducing consumption of carbonated drinks would prevent weight gain in children. The project took place in six junior schools with children aged seven to 11 years old, and classrooms were randomized to either the intervention group or the control group for one year. The intervention group received a nutrition education program one hour per term that focused on reducing intake of carbonated beverages and increasing water intake. The control group did not receive the program. Height and weight were measured at baseline, six months and one year to determine BMI and weight status. Beverage intake was assessed using three-day beverage diaries collected at baseline and the end of the trial. The final sample included 29 clusters (14 control, 15 intervention) that included 574 children (279 control, 295 intervention; mean age = 8.7 years) who remained in the study at 12 months. At 12 months, consumption of carbonated drinks decreased in the intervention group compared to the control group, and the mean percentage overweight and obese children increased in the control clusters 7.5%, while it decreased in the intervention group by 0.2%.

Cohort Studies (17)

Berkey CS et al, 2004 (neutral quality) analyzed data from a prospective cohort study in the US to examine the relationship between sugar-added beverage intake and adolescent weight change. Subjects were from the Growing Up Today Study, were recruited in 1996 when they were nine to 14 years old and followed up one to two years later in 1997 to 1998. Children self-reported height and weight, which were used to calculated BMI. Beverage intake was assessed using a self-administered food-frequency questionnaire (FFQ). The final sample included 11,755 children (5,067 boys, 6,688 girls). After adjusting for energy intake, consumption of sugar-added beverages at baseline and change in sugar-added beverage intake were not associated with weight gains over one year.

Blum JW et al, 2005 (neutral quality) used prospective cohort data from the US to determine differences in beverage consumption from baseline to year two follow-up in all subjects and based on BMI z-scores and identify predictors of BMI z-score at year two. Subjects were categorized into four groups based on BMI z-score at baseline: 1) Normal weight, BMI z-score less than 1.0 at baseline and year two; 2) Overweight, BMI z-score 1.0 or more at both baseline and year two; 3) Gained weight, BMI z-score of less than 1.0 at baseline and a BMI z-score of 1.0 or more at year two; and 4) Lost weight, BMI z-score 1.0 or more at baseline and a BMI z-score of less than 1.0 at year two. A 24-hour diet recall was used to determine total caloric intake and beverage consumption at baseline and year two. The final sample included 166 children (92 girls, 74 boys; age 9.3 years at baseline and 10.7 at year two). Results showed an inverse association between change in SSB

consumption (percent energy) for overweight subjects (R= -0.63; P<0.05) and subjects who gained weight (R= -0.94; P<0.05).

Dubois et al, 2007 (positive quality) used data from a longitudinal study conducted in Canada to examine the relationship between sugar-sweetened beverage consumption between meals and the prevalence of overweight among preschoolers participating in the Longitudinal Study of Child Development in Quebec (1998 to 2002). Children were seen at five months and then at ages 2.5, 3.5, and 4.5 years. Dietary intake data was collected using a 24-hour dietary recall and aFFQ. Children's height and weight were measured, and BMI was calculated. The final sample included 1,499 children. Children who did not consume SSBs between from ages 2.5 to 4.5 years had lower rates of overweightcompared to children who were regular consumers (consumed SSBs between meals four to six times per week) at 4.5 years (7% vs. 15%). Regular SSB consumption between meals more than doubled the odds of being overweight at age 4.5 years (OR=2.06, 95% CI: 1.003 to 4.563, P<0.05).

Fiorito LM, 2009 (positive quality) used data from a prospective cohort study in the US to examine whether beverage intake of girls at age five predicted adiposity from age five to 15 years. The participants and their families were reassessed every two years at ages seven, nine, 11, 13 and 15. At each assessment, beverage intake (milk, fruit juice and sweetened beverages) and energy intake were assessed by using three 24-hour recalls. Percentage body fat [dual energy X-ray absorptiometry (DEXA)] and waist circumference (WC) were measured. Height and weight were measured and used to calculate BMI. The final sample included 166 girls. Greater consumption of sweetened beverages at age five years (two or more servings per day) was associated with adiposity (higher percentage body fat, WC and weight status) from age five years to age 15 years.

Johnson et al, 2007 (positive quality) used data from prospective cohort study conducted in the United Kingdom to assess whether SSB consumption increases fatness in children, using a subsample of the Avon Longitudinal Study of Parents and Children. Diet was assessed at ages five years and seven years using three-day diet diaries. Fat mass was measured at age nine using DEXA. The final sample included 521 children at ages five years and nine years, and 682 children at ages seven years and nine years. There was no evidence of an association between SSB consumption at ages five and seven and fatness at age nine.

Kral et al, 2008 (neutral quality) used a prospective cohort design study from the US to test whether changes in beverage consumption patterns from age three to five years were associated with changes in children's BMI z-score and WC. Beverage intake was assessed using three-day weighed food records. Measured height and weight were used to calculate BMI. The final sample included 45 children at age three years, 48 at age four years, 42 at age five years and 42 at age six years. Results showed no significant (NS) associations between change in consumption of from individual beverage categories and change in BMI z-score. A greater three-year increase in soda intake was associated with an increased change in WC (P<0.05). Also, over the study time period, greater increases in calories (P<0.02) and percent energy (P<0.02) consumed from all types of beverages was inversely related to changes in children's WC.

Kvaavik et al, 2005 (neutral quality) analyzed data from a prospective cohort study conducted in Norway to test the association of long-term soft drink intake with body weight, using participants from the Oslo Youth Study. Subjects were followed from age 15 years to age 33 years. Data about soft drink intake was collected via questionnaire in 1981, 1979, 1991 and 1999. Weight and height were measured in 1981 and 1979 and self-reported in 1999. The final sample included 422 subjects (215 women, 207 men; mean age 15 years at baseline). There were no differences in BMI, overweight or obesity between long-term high and low soft drink consumers.

Libuda et al, 2007 (neutral quality) used a prospective cohort design study from Germany to test for an association between beverage consumption and body-weight status as part of the DONALD (Dortmund Nutritional and Anthropometric Longitudinally Designed) study using data from subjects aged nine to 18 years collected over a five-year period. Beverage intake was assessed using three-day weighed food records. Height and weight were measured to determine BMI, and body fat percentage was determined using skinfold measurements. The final sample included 244 subjects (125 boys, 119 girls; mean age = 12 years at baseline). In boys, neither baseline consumption nor change in consumption of soft drinks was associated with changes in BMI or percent body fat. In girls, change in beverage intake significantly predicted change in BMI-SDS; for each additional MJ of energy-containing beverage consumed, BMI-SDS of girls increased by 0.07 units (P=0.01). However, the association between soft drink consumption and change in BMI was borderline significant (+0.055 BMI-SDS per MJ increase in soft drink consumption; P=0.08). There was no association between percent body fat and beverage intake in girls.

Ludwig DS et al, 2001 (positive quality) used data from a prospective cohort study in the US to examine the relationship between consumption of SSBs and prevalence of obesity in children. Children were followed for 19 months. Height and weight were measured to determine BMI and weight status. Dietary intake data was collected using a youth FFQ. The final sample included 548 children (263 girls, 285 boys; mean age = 11.7 years at baseline). Results showed that for each additional serving of sugar-sweetened beverage consumed, BMI ($0.24kg/m^2$, 95% CI: 0.10 to 0.39; P=0.03) and frequency of obesity (1.6, 95% CI: 1.14 to 2.24, P=0.02) increased significantly. Baseline consumption of SSB intake was also independently associated with change in BMI ($0.81kg/m^2$, 95% CI: 0.09 to 0.27, P=0.02).

Mrdjenovic G and Levitsky DA, 2003 (neutral quality) analyzed data from a cohort of children in the US to study the effects of excessive sweetened drink consumption on energy intake, nutrient intake and weight. Daily dietary intakes of children attending a summer day camp were collected over four to eight weeks using a combination of parent report of food consumed at home and weighed intakes of food consumed at camp. Weight and height were measured to determine BMI. The final sample included 30 children (11 girls, 19 boys; ages six to 13 years). Children at the highest level of sweetened drink consumption (more than 16oz per day) gained more weight during the study (1.12±0.7kg) than children who consumed on average between 6oz and 16oz of sweetened drinks per day (0.32 to 0.48±0.4kg), though the difference was not significantly (NS) different.

Mundt et al, 2006 (positive quality) used data from a prospective cohort study conducted in Australia to examine the relationship between physical activity and sugar-sweetened drink intake and the development of total body fat mass. Participants were between eight and 15 years at baseline, and were followed for seven years. Dietary intake data was collected via 24-hour recall collected three times a year in the first three years and then two times a year thereafter. Height and weight were measured, and body composition was determined using DEXA. The final sample included 228 children (113 boys, 115 girls). The results showed no relationship between sugar-sweetened drink consumption and fat-mass development of males or females.

Newby PK et al, 2004 (positive quality) analyzed data from a cohort of children in the US to examine the association between beverage consumption, including soda intake and changes in weight and BMI in preschool children. Children were participants in the North Dakota Women, Infants and Children (WIC) program, who had two visits between six and 12 months apart. Women, infants and children staff measured height and weight, which were used to determine BMI. Dietary data were collected using a FFQ. The final sample included 1,345 subjects (mean age at baseline = 3 years). Results showed that change in weight was not related to soda intake.

Phillips SM et al, 2004 (positive quality) analyzed data from a cohort of children in the US to examine the relationship between energy-dense snack food intake and longitudinal weight and body fat in adolescents. Subjects were from the MIT Growth and Development Study, and were recruited in fourth and fifth grade and followed annually until four years post-menarche. Measured height and weight were used to determine BMI, body fat was assessed using bioelectrical impedance and dietary intake was assessed using an FFQ. The final sample included 178 girls (mean 10 years at baseline, mean 17 years at follow-up). There was a significant relationship between the percentage of calories consumed from soda and BMI, even after adjusting for covariates. Subjects in the third and fourth quartiles of percentage of calories from soda had BMI z-scores that were 0.17 units higher than subjects in the first quartile. When these data were stratified by menarcheal status, the relationship was only significant during the post-menarcheal period. Soda intake was not related to percent body fat.

Striegel-Moore et al, 2006 (positive quality) used data from a longitudinal study conducted in the US to examine the relationship between beverage consumption and BMI. Subjects were participants in the National Heart, Lung and Blood Institute (NHLBI) Growth and Health Study. Girls participated in ten approximately annual assessment visits, and were ages nine to 10 years at baseline. Dietary intake was assessed using three-day food records collected at visits one to five, seven, eight and 10. Height and weight were measured annually to determine BMI. The final sample included 2,371 girls. Soda consumption predicted a significant increase in BMI (0.011±0.005 per 100g per day of soda; P<0.05).

Sugimori et al, 2004 (neutral quality) analyzed data from a prospective cohort study in Japan to examine dietary factors associated with BMI. Children were from the Toyama Birth Cohort Study, which followed children born in 1989 to 1990 until 1996. This paper examines children from age three years to age six years. Height and weight were measured to determine BMI, and a questionnaire was used to evaluate children's diet. The final sample included 8,170 children (4,176 boys, 3,994 girls). Results showed no association between consumption of soft drinks as part of a late-night meal and weight in this cohort of children.

Tam et al, 2006 (neutral quality) used data from a prospective cohort study to determine the relation between soft drink consumption in mid-childhood and BMI status in early adolescence in a cohort of Australian children from the "Nepean Study." Children were followed for five years. Dietary intake was assessed using three-day food records collected at baseline. BMI and BMI z-scores were calculated from age and sex-specific reference values using height and weight measurements taken at baseline and five-year follow-up. Participants were categorized into groups based on BMI: 1) Acceptable BMI at baseline and follow-up; 2) BMI gainers (acceptable BMI at baseline and overweight or obese at follow-up); 3) BMI losers (overweight or obese at baseline, but acceptable BMI at follow-up); and 4) overweight or obese at both baseline and follow-up. The final sample included 281 children (141 boys, 140 girls; mean age = 7.7 years at baseline). Results showed that meanCHO intake from soft drink or cordial was 10g higher (P=0.002) per day in children who were overweight or obese at follow-up compared to those who had acceptable BMI, and 23g higher than those who were BMI losers (P=0.019).

Welsh et al, 2005 (positive quality) conducted a retrospective cohort study in the US to examine the longitudinal association between the consumption of all commonly consumed sweet drinks and the incidence and persistence of overweight among preschool children. Children were aged two to three years at baseline and were followed for one year. Weight status was determined using measured height and weight. Sweet drink intake was assessed using a FFQ. The final sample included 10,904 children (50.1% female; mean age at baseline = 34 months). Children who were at risk of overweight at baseline and consumed one to less than two drinks a day, two to less than three drinks

a day and three or more drinks a day, respectively, were 2.0 (95% CI: 1.3 to 3.2), 2.0 (95% CI: 1.2 to 3.2), and 1.8 (95% CI: 1.1 to 2.8) times as likely to become overweight as the referent (zero to less than one drink a day). Children who were overweight at baseline and consumed zero to one drink a day, one to less than two drinks a day, two to less than three drinks a day and three or more drinks a day, respectively, were 2.1 (95% CI: 1.3 to 3.4), 2.2 (95% CI: 1.4 to 3.7) and 1.8 (95% CI: 1.1 to 2.9) times as likely to remain overweight as the referent (zero to less than one drink a day).

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Author, Year, Study Design, Class, Rating	Participants	Methods	Outcomes
Berkey CS, Rockett HRH et al, 2004 Study Design: Cohort study (longitudinal, prospective) Class: B Rating: ⬤	N=11,755 children (5,067 boys, 6,688 girls). Location: US.	Subjects were from the Growing Up Today Study (GUTS), were recruited in 1996 when they were nine to 14 years old and followed up one to two years later from 1997 to 1998. Children self-reported height and weight, which were used to calculated BMI. Beverage intake was assessed using a self-administered FFQ.	After adjusting for energy intake, consumption of sugar-added beverages at baseline and Δ in sugar-added beverage intake were not associated with weight gains over one year.
Blum JW, Jacobsen DJ et al, 2005 Study Design: Prospective Cohort Study Class: B Rating: ⬤	N=166 children (92 girls, 74 boys). Mean age at baseline: 9.3 years. Location: US.	Subjects were categorized into four groups based on BMI Z-score at baseline: 1) Normal weight, BMI z-score <1.0 at baseline and year two 2) Overweight, BMI z-score ≥1.0 at both baseline and year two 3) Gained weight, BMI z-score of <1. 0 at baseline and a BMI z-score of ≥1.0 at year	Results showed an inverse association between Δ in SSB consumption (% energy) for overweight subjects (R= -0.63; P<0.05) and subjects who gained weight (R= -0.94; P<0.05).

		two	
		4) Lost weight, BMI z-score ≥1.0 at baseline and a BMI z-score of <1.0 at year two. A 24-hour diet recall was used to determine total caloric intake and beverage consumption at baseline and year year.	
Dubois et al 2007 Study Design: Longitudinal Study Class: B Rating: ⊕	N=499 children. Location: Canada.	Children were seen at five months and then at ages 2.5, 3.5 and 4.5 years. Dietary intake data was collected using a 24-hour dietary recall and an FFQ. Children's height and weight were measured, and BMI was calculated.	Children who did not consume SSBs between from ages 2.5 to 4.5 years had lower rates of overweight compared to children who were regular consumers (consumed SSBs between meals four to six times a week) at 4.5 years (7% vs. 15%). Regular SSB consumption between meals more than doubled the odds of being overweight at age 4.5 years (OR=2.06, 95% CI: 1.003 to 4.563, $P<0.05$).
Ebbeling CB, Feldman HA et al, 2006 Study Design: Randomized controlled trial Class: A Rating: ⊕	N=103 (53 in the intervention group, 50 in the control group). Mean age: 16 years. Location: US.	Subjects in the intervention group received weekly home deliveries of non-caloric beverages for 25 weeks, with a target consumption of four servings per day, while those in the control group were asked to continue their usual beverage consumption habits. Two 24-hour dietary and physical activity recall interviews were conducted at baseline and	Consumption of SSBs ↓ by 82% in the intervention group ($P<0.0001$), while consumption in the control group remained the same. Δ in BMI was $0.07\pm0.14kg/m^2$ in the intervention group and $0.21\pm0.15kg/m^2$ in the control group. However, the difference between groups ($-0.14\pm0.21kg/m^2$) was NS. However, baseline BMI was a significant effect modifier; among subjects in the upper baseline BMI tertile, BMI Δ

		after 25 weeks, and weight and height were measured.	differed between the intervention (-0.63±0.23kg/m^2) and control groups (+0.12±0.26kg/m^2), and the difference (-0.75±0.34kg/m^2) was significant (P=0.03).
Fiorito LM, Marini M et al, 2009 Study Design: Prospective Cohort Study Class: B Rating: ⊕	N=166 girls. Age at baseline: Five years. Location: US.	The participants and their families were reassessed every two years at ages seven, nine, 11, 13 and 15. At each assessment, beverage intake (milk, fruit juice and SSBs) and energy intake were assessed by using three 24-hour recalls. Percentage body fat (DEXA) and WC were measured. Height and weight were measured and used to calculate BMI.	Greater consumption of SSBs at age five years (two or more servings a day) was associated with adiposity (↑ percentage body fat, WC and weight status) from age five years to age 15 years.
James J, Thomas P et al 2004 Study Design: Randomized controlled trial Class: A Rating: ⊕	N=29 clusters (14 control, 15 intervention) with 574 children (279 control, 295 intervention; mean age = 8.7 yrs) Location: United Kingdom	The project took place in 6 junior schools with children aged 7-11 years old, and classrooms were randomized to either the intervention group or the control group for 1 year. The intervention group received a nutrition education program one hour per term that focused on reducing intake of carbonated beverages, and increasing water intake. The control group did not receive the program. Height and weight were measured at baseline, 6 months, and 1 year to determine BMI and weight status. Beverage intake was assessed using 3-day	At 12 months, consumption of carbonated drinks decreased in the intervention group compared to the control group, and the mean percentage overweight and obese children increased in the control clusters 7.5%, while it decreased in the intervention group by 0.2%.

		beverage diaries collected at baseline and the end of the trial.	
Johnson et al 2007 Study Design: Prospective Cohort Study Class: B Rating: ⊕	N=521 at age five and nine years. N=682 at age seven and nine years. Location: United Kingdom.	Diet was assessed at ages five years and seven years using three-day diet diaries. Fat mass was measured at age nine using DEXA.	There was no evidence of an association between SSB consumption at ages five and seven and fatness at age nine.
Kral TV, Stunkard AJ et al, 2008 Study Design: Cross-Sectional Study Class: D Rating: ◐	N=45 at age three years. N=48 at age four years. N=42 at age five years. N=42 at age six years. Location: US.	Children were followed from age three years to age six years. Beverage intake was assessed using three-day weighed food records. Measured height and weight were used to calculate BMI.	NS associations between Δ in consumption from individual beverage categories and Δ in BMI z-score. A greater three-year ↑ in soda intake was associated with an ↑ Δ in WC (P<0.05).
Kvaavik, Andersen and Klepp 2005 Study Design: Prospective Cohort Study Class: B Rating: ◐	N=422 (215 women, 207 men; mean age 15 years at baseline). Location: Norway.	Subjects were followed from age 15 years to age 33 years. Data about soft drink intake was collected via questionnaire in 1981/1979, 1991 and 1999. Weight and height were measured in 1981/1979 and self-reported in 1999.	There were no differences in BMI, overweight or obesity between long-term high and low soft drink consumers.
Libuda L, Alexy U et al, 2008 Study Design:	N=244 subjects (125 boys, 119 girls). Mean age: 12	Subjects aged nine to 18 years were followed over a five-year period. Beverage intake was	In boys, neither baseline consumption nor Δ in consumption of soft drinks was associated with Δ in BMI or

Prospective Cohort Study Class: B Rating:	years at baseline. Location: Germany.	assessed using three-day weighed food records. Height and weight were measured to determine BMI, and body fat percentage was determined using skinfold measurements.	percent body fat. In girls, Δ in beverage intake significantly predicted Δ in BMI-SDS; for each additional mJ of energy-containing beverage consumed, BMI-SDS of girls $\uparrow$ by 0.07 units (P=0.01). However, the association between soft drink consumption and Δ in BMI was borderline significant (+0.055 BMI-SDS per mJ $\uparrow$ in soft drink consumption; P=0.08). There was no association between percent body fat and beverage intake in girls.
Ludwig DS, Peterson KE, et al 2001 Study Design: Prospective Cohort Study Class: B Rating:	N=548 children (263 girls, 285 boys). Mean age at baseline: 11.7 years. Location: US.	Children were followed for 19 months. Height and weight were measured to determine BMI and weight status. Dietary intake data was collected using a youth FFQ.	For each additional serving of SSB consumed, BMI ($0.24 kg/m^2$, 95% CI: 0.10 to 0.39; P=0.03) and frequency of obesity (1.6, 95% CI: 1.14 to 2.24, P=0.02) $\uparrow$ significantly. Baseline consumption of SSB intake was also independently associated with Δ in BMI ($0.81 kg/m^2$, 95% CI: 0.09 to 0.27, P=0.02).
Mrdjenovic G, Levitsky DA 2003 Study Design: Longitudinal Cohort (or nonrandomized trial using own subjects as controls?) Class: B Rating:	N=30 children (11 girls, 19 boys; ages 6-13 yrs) Location: United States	Daily dietary intakes of children attending a summer day camp were collected over 4 to 8 weeks using a combination of parent report of food consumed at home, and weighed intakes of food consumed at camp. Weight and height were measured to determine BMI.	Children at the highest level of sweetened drink consumption (>16 oz/day) gained more weight during the study (1.12±0.7 kg) than children who consumed on average between 6 oz and 16 oz of sweetened drinks per day (0.32-0.48±0.4 kg), though the difference was not significantly different.

Mundt CA, Baxter-Jones AD et al, 2006 Study Design: Prospective Cohort Study Class: B Rating: +	N=228 children (113 boys, 115 girls). Location: Australia.	Participants were between eight and 15 years at baseline, and were followed for seven years. Dietary intake data was collected via 24-hour recall, and collected three times a year in the first three years and then two times a year thereafter. Height and weight were measured, and body composition was determined using DEXA.	The results showed no relationship between SSB consumption and fat-mass development of males or females.
Newby PK, Peterson KE et al, 2004 Study Design: Cohort study (longitudinal, retrospective) Class: B Rating: +	N=1,345 subjects. Mean age at baseline: Three years. Location: US.	Children were participants in the North Dakota WIC program, who had two visits between six and 12 months apart. WIC staff measured height and weight, which were used to determine BMI. Dietary data were collected using a FFQ.	Δ in weight was not related to soda intake.
Phillips SM, Bandini LG et al, 2004 Study Design: Cohort study (longitudinal, prospective) Class: B Rating: +	N=178 girls. Mean age: 10 years at baseline; 17 years at follow-up. Location: US.	Subjects were from the MIT Growth and Development Study, and were recruited in fourth and fifth grade and followed annually until four years post-menarche. Measured height and weight were used to determine BMI, body fat was assessed using bioelectrical impedance. Dietary intake was	There was a significant relationship between the percentage of calories consumed from soda and BMI, even after adjusting for covariates. Subjects in the third and fourth quartiles of percentage of calories from soda had BMI z-scores that were 0.17 units higher than subjects in the first quartile. When these data were stratified by menarcheal status, the relationship was only significant during the post-menarcheal

		assessed using an FFQ.	during the post-menarcheal period. Soda intake was not related to percent body fat.
Striegel-Moore, Thompson et al 2006 Study Design: Longitudinal Study Class: B Rating: ⊕	N=2,371 girls. Location: US.	Subjects were participants in the NHLBI Growth and Health Study. Girls participated in ten approximately annual assessment visits, and were ages nine to 10 years at baseline. Dietary intake was assessed using three-day food records collected at visits one to five, seven, eight and 10. Height and weight were measured annually to determine BMI.	Soda consumption predicted a significant ↑ in BMI (0.011 ± 0.005 per 100g per day of soda; $P<0.05$).
Sugimori H, Yoshida K et al 2004 Study Design: Cohort (longitudinal, prospective) Class: B Rating: ⦾	N=8,170 children (4,176 boys, 3,994 girls). Location: Japan.	Children were from the Toyama Birth Cohort Study, which followed children born in 1989 to 1990 until 1996. This paper examines children from age three years to age six years. Height and weight were measured to determine BMI, and a questionnaire was used to evaluate children's diet.	Results showed no association between consumption of soft drinks as part of a late-night meal and weight in this cohort of children.
Tam CS, Garnett SP et al, 2006 Study Design: Prospective Cohort Study Class: B	N=281 children (141 boys, 140 girls). Mean age = 7.7 years at baseline. Location: Australia.	Children were followed for five years. Dietary intake was assessed using three-day food records collected at baseline. BMI and BMI z-scores were calculated from age	Results showed that mean CHO intake from soft drink or cordial was 10g ↑($P=0.002$) per day in children who were overweight or obese at follow-up, compared to those who had acceptable BMI, and 23g ↑ than those who were BMI losers ($P=0.019$).

Rating: ⬤		and sex-specific reference values using height and weight measurements taken at baseline and five-year follow-up.	
Welsh JA, Cogswell ME et al, 2005 Study Design: Retrospective Cohort Study Class: B Rating: ✚	N=10,904 children (50.1% female). Mean age at baseline: 34 months. Location: US.	Children were aged two to three years at baseline, and were followed for one year. Weight status was determined using measured height and weight. Sweet drink intake was assessed using a FFQ.	Children who were at risk of overweight at baseline and consumed one to < two drinks a day, two to < three drinks a day and three or more drinks a day, respectively, were 2.0 (95% CI: 1.3 to 3.2), 2.0 (95% CI: 1.2 to 3.2) and 1.8 (95% CI: 1.1 to 2.8) times as likely to become overweight as the referent (zero to < one drink a day). Children who were overweight at baseline and consumed zero to < one drink a day, one to < two drinks a day, two to < three drinks a day and three or more drinks a day, respectively, were 2.1 (95% CI: 1.3 to 3.4), 2.2 (95% CI: 1.4 to 3.7), and 1.8 (95% CI: 1.1 to 2.9) times as likely to remain overweight as the referent (zero to < one drink a day).

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

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